observability :-

change in x ⟶ change in y

$$y = Cx$$

↳ C : non-zero vector

$$[1 \quad 0 \quad 0 \quad 0]$$

A = observer canonical form

Analysis $\Rightarrow$ T.F. $= C(SI-A)^{-1}B$ (for LTI systems)

Design :-

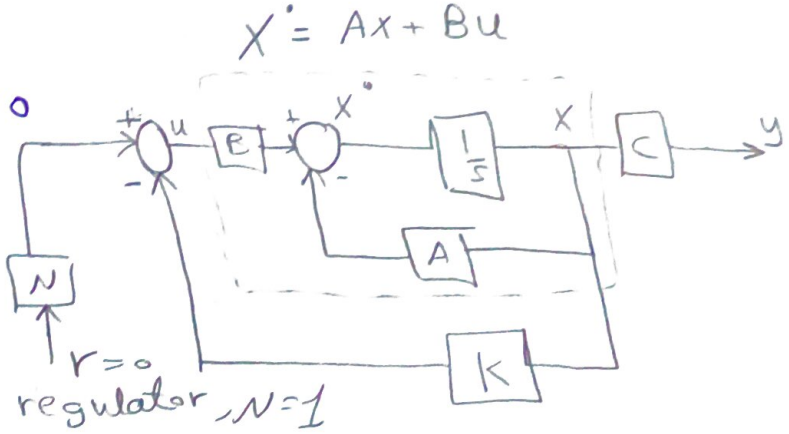
Desired closed loop ch. equation

$$\alpha_d(s) = 0$$

In State space

$$O.L.T.F \left| SI-A \right| = 0$$

r = r ≠ 0.
r = 0 ⇒ we use this case for this semester.



$$u = 0 - Kx$$

state feedback

OR r = value
Servo Mechanism
N = ✓✓

C.L. system

$$x' = Ax - BKx$$
$$x' = (A-BK)x \Rightarrow \text{C.L. ch. eqn} = \left| SI-(A-BK) \right| = 0$$

Control Target :-

Choose K (vector) such that

$$|SI - A + BK| = \alpha_c(S)$$

(1) Coefficient comparison

(2) Ackerman form $K = [0 \; 0 \; \cdots \; 1] \, M_c^{-1} \, \alpha_c(A)$

for Controllable form

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1 & -a_2 & -a_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$A - BK = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1 & -a_2 & -a_3 \end{bmatrix} - \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ K_1 & K_2 & K_3 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_1 - K_1 & -a_2 - K_2 & -a_3 + K_3 \end{bmatrix}$$

Given $\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -6 & -7 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$

Design state feedback controller such that desired C.L. Ch. eqn

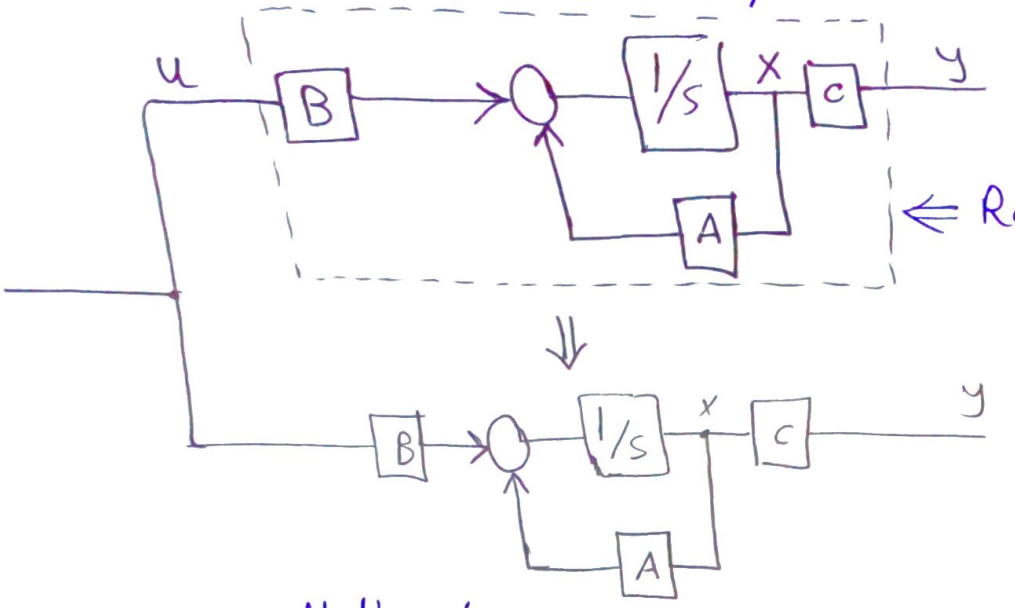
$$\alpha_c(S) = S^3 + 12S^2 + 47S + 60$$

$$SI - A + BK = \begin{bmatrix} S & 0 & 0 \\ 0 & S & 0 \\ 0 & 0 & S \end{bmatrix} - \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 - K_1 & -6 - K_2 & -7 - K_3 \end{bmatrix}$$

$$|SI - A + BK| = \begin{vmatrix} S & -1 & 0 \\ 0 & S & -1 \\ 3 + K_1 & 6 + K_2 & S + 7 + K_3 \end{vmatrix}$$

$$S^3 + (7 + K_3)S^2 + (6 + K_2)S + (3 + K_1) = 0$$

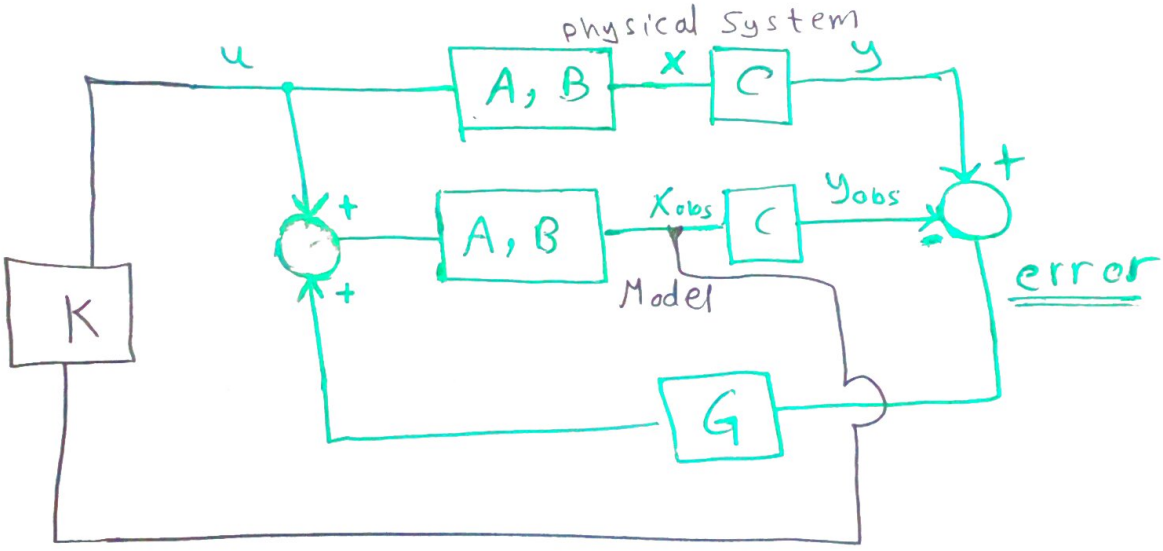
* State Observers (Estimators) :-



← Real Model

← Mathematical Model with eqn

Mathematical Model ولا Real Model بنقارن بين الـ



$$G = \alpha_0(A)\, M_0^{-1} \begin{bmatrix} 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix}$$

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take care of

① Models Uncertainity (Stochastic form) ⟸

② sensor Noise (Stoch. form) we model the uncertainity

في الحالة دي مقدرش أعتمد على المعادلة الرياضية وضفا ل مع الموجود